White Paper

ECO2S 2-Stage Electronic Unit Heater Control Study

Tighter Temperature Control and Energy Savings Under Part-Load Conditions

Prepared for Consulting Engineers, Architects, Contractors, Facility Owners, and End Users

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Smart Heating Solutions

Executive Summary

Electric unit heaters are frequently installed in garages, workshops, warehouses, maintenance areas, mechanical rooms, and similar spaces where ducted HVAC systems may be impractical or cost prohibitive. These spaces often experience dynamic heating loads caused by outdoor temperature, infiltration, insulation levels, overhead doors, and intermittent occupancy.

Traditional mechanical thermostat control typically operates an electric unit heater as a single-stage, full-output device. This method is simple and reliable, but it can produce wider room temperature swings, repeated full-power heating cycles, and unnecessary heating above the desired setpoint when the space does not require full-capacity operation.

The ECO2S controller is an electronic thermostat and control platform designed specifically for King electric unit heaters. It provides 2-stage heating control, digital temperature sensing, improved response near the setpoint, and reduced temperature differential compared with traditional mechanical thermostat operation.

King Electrical Manufacturing conducted a controlled comparison between two identical KBP electric unit heaters. One unit used a conventional mechanical thermostat. The other used King's ECO2S 2-stage electronic controller. Current, voltage, indoor temperature, and outdoor temperature were recorded during multiple test periods.

The test results support a practical specification conclusion: ECO2S 2-stage electronic control improves temperature stability and can reduce energy consumption when the space heating load allows the heater to operate at reduced output.
Under observed part-load conditions, ECO2S reduced measured electrical current draw by up to 33.2%. Reduced electrical current draw can provide up to 30% energy cost savings under similar part-load operating conditions.

// Specifier Takeaways

- ECO2S is a factory-integrated 2-stage electronic control designed to match heater output more closely to the actual space heating load.
- Testing showed substantially tighter temperature control than mechanical thermostat operation.
- Testing showed measured energy savings up to 33% under observed part-load operating conditions.
- Lower-setpoint applications reduce the indoor-outdoor Delta T (ΔT) - the difference between the indoor setpoint and outdoor temperature - which can extend Stage 1 operation and create strong energy-saving opportunities.
- Higher building insulation reduces heat loss and may extend low-stage heating time, potentially increasing energy savings compared with the lightly insulated test environment.
- When the heater must operate at full capacity, ECO2S should be specified for control precision and comfort rather than energy savings.
- ECO2S controlled heaters should be considered for warehouses, unoccupied spaces, and freeze protection applications because the target space temperature is much lower than comfort-heating setpoints, reducing heat loss and increasing the likelihood that low-stage heating can satisfy the load.

At high-load conditions where the unit must operate at full heating capacity, ECO2S energy use is comparable to a mechanically controlled unit heater. Under these conditions, the actual energy savings are negligible. However, improved temperature control reduces cycling and improves user comfort.

Lower-temperature applications can create strong opportunities for ECO2S because a lower thermostat setpoint reduces the indoor-outdoor ΔT and lowers the building heat loss that the heater must replace. Warehouse, freeze protection, and unoccupied-operation applications are therefore important candidates for 2-stage control, especially when the building is insulated well enough to let the heater operate in Stage 1 for extended periods.

Why This Matters to Specifying Engineers and End Users

Unit heaters are often selected as commodity products. The lowest initial-cost heater may appear acceptable at the time of purchase, but poor temperature control, wider temperature swings, and repeated full-output cycling can create comfort complaints and higher operating costs over time.

For a specifying engineer, the objective is not only to provide heat. The objective is to select a product that delivers reliable comfort, predictable operation, and a lower total cost of ownership. For an end user or facility owner, the value is practical: a more stable space temperature, less overshoot, less unnecessary full-output heating when the space does not require it, and potential energy savings under part-load operation.

Recommendation

For applications requiring improved comfort control, reduced temperature swing, and part-load energy savings, specify electric unit heaters with factory-integrated 2-stage electronic control. The controller should provide staged heating operation, digital temperature sensing, and a reduced temperature differential compared with mechanical thermostat control.

Best-Fit Applications

- Warehouses, distribution centers, and unoccupied spaces where lower setpoints are acceptable and heat loss varies with door openings.
- Freeze-protection applications where the target setpoint is well below occupied comfort-heating temperatures.
- Garages and vehicle service areas.
- Workshops and maintenance areas.
- Mechanical rooms and utility spaces.
- Commercial and industrial spaces with intermittent occupancy or variable infiltration.
- Retrofit applications where improved comfort and operating cost are important without changing the entire heating system.

Application Temperature Guidelines and Energy-Savings Opportunity

Electric unit heaters are used in different building types, and the appropriate heating strategy depends on occupancy, activity level, building use, and freeze-protection requirements. The thermostat setpoint also affects the indoor-outdoor Delta T (ΔT) - the difference between the indoor setpoint and the outdoor temperature. For a given outdoor temperature, a lower indoor setpoint creates a lower ΔT, reduces building heat loss, and gives ECO2S more opportunity to maintain the space in low-stage heating.

This is important for specification. A heater serving an occupied office at 68˚ F may face a much higher ΔT than a heater serving a warehouse at 55˚ F or freeze protection at 45˚ F under the same outdoor condition. Because the warehouse or freeze-protection applications have lower heat-loss requirements, the heater is more likely to remain in Stage 1 for longer periods. That makes warehouses and freeze protection the strongest application opportunities for ECO2S energy savings, provided the heater is properly sized and the building envelope allows reduced-output operation.

Building insulation is a key factor. The test environment was similar to a lightly insulated shop space. In a better-insulated building, heat loss is lower at the same ΔT, which can extend the amount of time the ECO2S-controlled heater operates in Stage 1. Longer Stage 1 operation may increase energy savings compared with the test case. Actual savings still depend on building envelope, infiltration, door openings, heater sizing, thermostat location, outdoor temperature, and operating schedule.

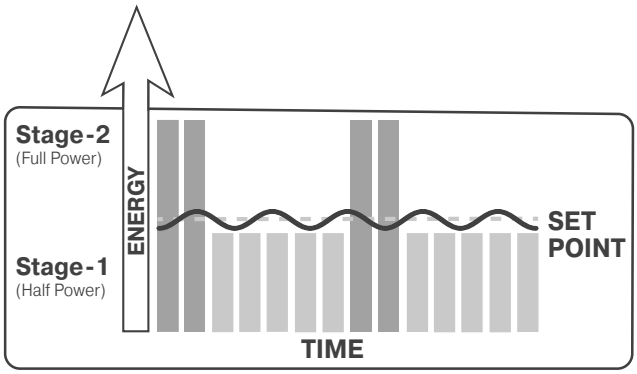
Application Type	Typical Setpoint Guidance	Design & Operating Considerations
Home & office comfort - occupied periods	About 68˚ F (20˚ C)	Common comfort setting for sedentary occupants. Higher comfort setpoints increase ΔT and may require more heating capacity than lower-temperature applications.
Home & office comfort - unoccupied or sleep periods	About 62˚ F (17˚ C)	Lowering the thermostat while away or during sleep periods reduces ΔT and heat loss when full comfort conditioning is not required.
Factory environments - active labor	About 62 ˚F (17˚ C)	Manufacturing work often involves physical movement that raises body temperature. Lower setpoints can maintain comfort without overheating workers during manual tasks.
Warehouses & distribution centers	About 55˚ F (13˚ C)	Lower setpoints and intermittent occupancy can reduce ΔT. Door openings still create variable load, making staged control useful when the unit can recover in low stage.
Freeze protection	About 45˚ F (7˚ C) minimum building target	Lower setpoints create a lower ΔT than comfort heating and can extend Stage 1 operation. This is a strong energy-saving opportunity when the space is properly insulated and vulnerable piping or equipment remains protected.

ECO2S Controller Overview

The ECO2S controller is an electronic thermostat and control platform designed specifically for King electric unit heaters. It provides 2-stage heating control, digital temperature sensing, improved response near the setpoint, and reduced temperature differential compared with traditional mechanical thermostat operation.

2-stage heating allows the heater to operate at reduced output during light or moderate heating demand and at full output when the space requires additional capacity. This helps the heater output more closely match the actual building heat loss.

- Stage 1:
  Reduced heating capacity for light or moderate demand.
- Stage 2:
  Full heating capacity when heating demand increases.
- Digital Sensing:
  More precise response near the setpoint.
- Improved Comfort:
  Reduced room temperature swing and overshoot.



Test Objective

The test program was designed to determine whether ECO2S 2-stage electronic control improves unit heater performance compared with a conventional mechanical thermostat. The comparison focused on three performance factors:

- Electrical energy consumption, evaluated using current and voltage measurements.
- Temperature stability, evaluated using room temperature data.
- Heater cycling behavior, evaluated through power draw patterns and time-on/time-off behavior.

Test Equipment and Environment

Two identical King KBP electric unit heaters were tested.
Both heaters used the same heating package and airflow system.
The primary difference between the units was the thermostat and control method.

Unit	Control Type	Purpose in Test
KBP2406-1-MB-ECO2S	ECO2S 2-stage electronic controller	Test unit
KBP2406-1-MB-ECO2S	Mechanical thermostat	Comparison unit

ECO2S 2-stage electronic control unit

Mechanical thermostat comparison unit

Testing was conducted in a test chamber environment that behaved similarly to a lightly insulated shop or work area. The heaters were mounted side-by-side on the same wall, approximately 6 feet above the floor. The heaters were operated independently during test periods, and thermostat probes were located at the rear of each heater.

Methodology Note

Because the heaters were tested during separate operating periods, the comparison was grouped by equivalent indoor-outdoor ΔT rather than by calendar time. This allowed the test to compare heater operation under similar heating-load conditions. The test was intended to compare relative controller performance, not to predict exact energy savings for every installation.

// Instrumentation

- Room temperature and outdoor temperature were recorded using J-type thermocouples connected to a thermocouple data logger.
- Heater current and voltage were recorded using a Triplett ACDL200 data logger.
- Electrical measurements were used to compare average electrical draw and estimate relative energy consumption.

// Test Procedure

- The first heater operated for a minimum 24-hour test period.
- Electrical and temperature data were recorded.
- The first heater was turned off.
- The second heater was activated for an equivalent test period.
- Data collection continued and the process was repeated to capture multiple heating cycles and environmental conditions.
- Outdoor temperature was monitored and data was grouped by equivalent indoor-outdoor ΔT to compare performance under similar load conditions.

Test installation with mechanical thermostat unit and ECO2S unit mounted side-by-side.

Key Results Summary

The test results show that ECO2S provides its strongest energy benefit during part-load operation, when the heater can maintain room temperature primarily in first-stage heating. Lower setpoints and better building insulation can increase the amount of time the heater operates in Stage 1, which is why freeze-protection and other lower-temperature applications are strong candidates for ECO2S energy savings.

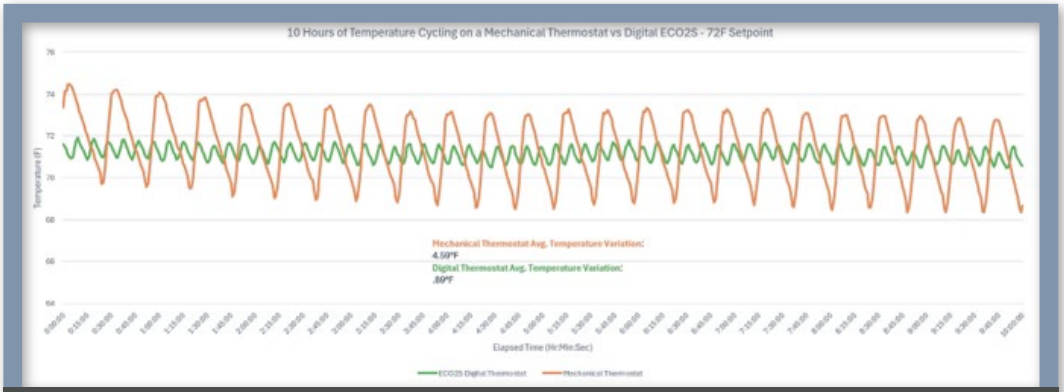
When heating demand requires sustained full-capacity operation, staged control does not create meaningful energy savings compared with mechanical thermostat control.

Test Condition	Mechanical Thermostat	ECO2S2-Stage Control	Specification Interpretation
Temperature stability at 72˚ F setpoint	4.59˚ F average amplitude	0.89˚ F average amplitude	ECO2S provided substantially tighter room temperature control.
30˚ F ΔT	Full-load operation	Full-load operation	Energy use is comparable at full load.
25˚ F ΔT	9.0 average amps	6.8 average amps	33.2% measured reduction
20˚ F ΔT	6.3 average amps	5.6 average amps	11.7% measured savings under moderate-load test condition.
15˚ F ΔT	5.2 average amps	4.8 average amps	9.0% measured savings under light-load test condition.

Result 1: Improved Temperature Stability

Mechanical thermostat operation produced wider temperature swings around the setpoint. ECO2S electronic control maintained a tighter room temperature band by using digital sensing and staged output control.

Control Method	Average Temperature Amplitude	Result
Mechanical thermostat	4.59˚ F	Wider temperature swing and greater overshoot potential
ECO2S electronic control	0.89˚ F	Tighter control near setpoint and improved comfort



Room temperature comparison showing reduced temperature swing with ECO2S electronic control.

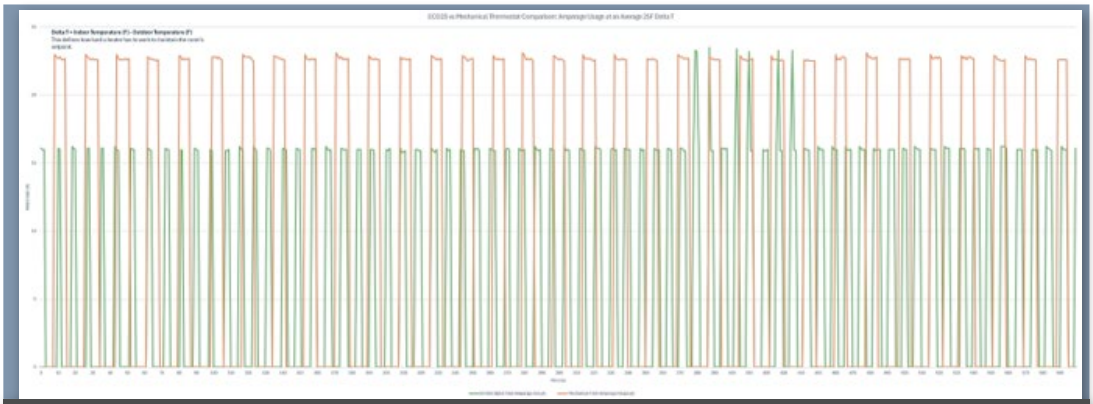
This temperature stability result is a strong specification argument for ECO2S. A more stable room temperature can improve occupant comfort, reduce complaints, and support a product selection based on control performance rather than initial cost alone.

Result 2: Energy Savings Under Part-Load Conditions

Measured current and voltage data were recorded during each test period and used to compare relative electrical consumption. Because both heaters used the same heating package and airflow system, differences in measured electrical use were primarily driven by the control method.

At a 25° F indoor-outdoor ΔT, the ECO2S-controlled heater maintained similar room temperature conditions while using approximately 66% of the measured electrical draw of the mechanically controlled heater. This supports a conservative claim of up to 30% energy savings under similar part-load operating conditions.

25° F ΔT Comparison	Mechanical Thermostat	ECO2S 2-stage Control
Time ON	238 minutes	243 minutes
Time OFF	362 minutes	357 minutes
Total measured amperage over 10 hours	5,401.1 A	4,055.6 A
Average amperage use	9.002 A	6.759 A
Average ΔT	24.99° F	25.01° F
Observed savings	Baseline	33.2% measured reduction



Ten-hour amperage comparison at an average 25° F ΔT.

Result 3: Why Savings Vary by Load Condition

ECO2S energy savings are not fixed. They depend on whether the heater has the opportunity to operate at reduced output. If the building load is light or moderate, ECO2S can spend more time in Stage 1 and reduce unnecessary full-output operation. If the building load is high enough that the heater must operate at full capacity, energy use is comparable to mechanical thermostat operation.

ΔT is a useful way to think about this relationship. A lower thermostat setpoint reduces the indoor-outdoor ΔT for the same outdoor condition. Lower ΔT reduces heat loss, which can extend low-stage operation. Better insulation further reduces heat loss and can allow ECO2S to operate in Stage 1 for longer periods than observed in the lightly insulated test environment. This is why warehouses, freeze protection, and unoccupied or lower-temperature operating modes are important energy-saving opportunities for ECO2S.

Indoor-Outdoor ΔT	Observed ECO2S Result	External Claim Language
15° F	9.0% measured savings	Energy savings may occur in light-load conditions, but savings vary.
20° F	11.7% measured savings	Energy savings may occur in moderate-load conditions, depending on application.
25° F	33.2% measured reduction	Use conservative up to 30% savings claim under similar part-load conditions.
30° F	Full-load operation	0% meaningful energy savings at full load; energy use is comparable to mechanical thermostat operation.

Warehouses, Unoccupied Spaces and Freeze-Protection Applications

Warehouses, unoccupied spaces, and freeze protection are the strongest application opportunities for ECO2S because the target temperature is often much lower than comfort-heating setpoints. For example, a building held at 45° F has a much lower ΔT than an occupied office held at 68° F under the same outdoor condition. The lower ΔT reduces heat loss and increases the opportunity for the heater to satisfy the space in Stage 1 instead of repeatedly cycling at full output.

This does not mean every installation will achieve the same savings measured in the test. Savings still depend on heater sizing, insulation, infiltration, thermostat location, door openings, outdoor temperature, and whether hidden piping or equipment remains above freezing. However, the application logic is favorable: lower setpoint plus lower heat loss creates more opportunity for low-stage operation.

Full-Load Operating Claim

When heating demand requires the heater to operate at full capacity, ECO2S should not be promoted as an energy-saving control. Under this condition, the appropriate external claim is negligible energy savings, because both the ECO2S-controlled heater and the mechanically controlled heater must operate at full output to satisfy the heating load. At full-load conditions, the specification value of ECO2S is improved electronic control, precise temperature sensing, and consistent heating.

// Engineering Interpretation

- 2-stage control improves efficiency when the heater can operate below full output. Savings are greatest when Stage 1 operation can satisfy the space load for meaningful periods.
- Lower thermostat setpoints reduce ΔT and building heat loss for the same outdoor condition, creating more opportunity for Stage 1 operation.
- Warehouses, unoccupied spaces, freeze-protection and other lower-temperature applications can be strong energy-saving opportunities when the building envelope supports low-stage operation.
- Higher insulation reduces heat loss and may extend low-stage heating time, potentially increasing energy savings beyond the lightly insulated test case.
- Reduced temperature overshoot improves comfort and can reduce unnecessary heating above the desired setpoint.
- At full-load operation, energy use is comparable to mechanical thermostat operation, and meaningful energy savings is negligible.

Claims

ECO2S 2-stage electronic control provides tighter temperature control and measured energy savings up to 30% under observed part-load operating conditions.

ECO2S reduced temperature swing from 4.59° F average amplitude with mechanical thermostat control to 0.89° F average amplitude with electronic control in King's controlled testing. Lower setpoint applications, including warehouses, unoccupied spaces, and freeze protection can create strong energy-saving opportunities because the lower indoor setpoint reduces ΔT and building heat loss, allowing the heater to spend more time in Stage 1 operation when properly sized.

Better-insulated buildings may extend low-stage heating time and may increase energy savings compared with the lightly insulated test environment.

Actual savings vary based on heater sizing, room heat loss, insulation, infiltration, outdoor temperature, setpoint, thermostat location, and operating schedule. When the heater must operate at full capacity, no meaningful energy savings are claimed. Savings are greatest when the heater can operate primarily in first-stage heating.

Conclusion

King's controlled testing showed clear operational differences between a conventional mechanical thermostat control and ECO2S 2-stage electronic control. ECO2S maintained tighter room temperature control, reduced unnecessary full-output operation under part-load conditions, and demonstrated measured energy savings up to 30% under observed part-load operating conditions.

The data also shows the importance of application fit. The strongest ECO2S energy-saving opportunities are applications where the heater can operate below full output for extended periods. Higher insulation values can further extend low-stage operation. Together, these conditions may increase the savings opportunity compared with the lightly insulated test case.

Overall, ECO2S is a practical specification upgrade for electric unit heater applications where comfort, temperature stability, professional-grade control, and part-load energy savings are valued. By matching heater output more closely to actual space heating demand, ECO2S supports a higher-value unit heater specification for consulting engineers, contractors, facility owners, and end users.

About the Author

Dean Wilson is Chief Executive Officer and Chief Technology Officer of King Electrical Manufacturing. As CTO, he leads the company's product and manufacturing technology strategy, including the implementation of automation and modernization initiatives that have expanded King's flexible, lean manufacturing capabilities. Dean has directed major product and control-system advancements across the KFUH and CKL product lines and led the development of King's Make-Up Air and PlatinumX product families. His leadership and technical vision continue to strengthen King's position as an innovative and trusted manufacturer in the electric heating industry.

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